International Journal of Textile
and Fashion Technology (IJTFT)
ISSN(P): 2250-2378; ISSN(E): 2319-4510
Vol. 6, Issue 1, Feb 2016, 1-14

EVALUATING THE EFFECT OF SEAMS ON COLOUR FASTNESS PROPERTIES OF TEXTILE FABRICS

MANAL A. SEIF[1] & MUNA M. HIJI[2]

[1]Associate Professor, Department of Apparel Design & Technology, Faculty of Applied Arts, HelwansUniversity, Egypt

[2]Associate Professor, Department of Fashion Design, Faculty of Designs, Umm Al-Qura University, Kingdom of Saudi Arabia

ABSTRACT

Textile fabric has many properties. Fastness property is one of the most important properties of them. It is the resistance of textile materials to resist against destructive factors such as abrasion, heat, light, wearing, acidic etc.

Colour fastness defined as the resistance of colour to fade or bleed of a dyed or printed textile material to various types of influences like water, light, rubbing, washing, perspiration etc. to which they are normally exposed in textile manufacturing and in daily use. This study concerns with the effect of seam parameters, such like seam allowance, seam types, stitch length and stitch types, on the colour fastness properties, such like wash fastness, light fastness and rub fastness.

KEYWORDS: Colour Fastness to Wash, Colour Fastness to Light, Colour Fastness to Wet Rubbing, Seam Allowance, Seam Types, Stitch Length, Stitch Type

Received: Dec 11, 2015; **Accepted:** Dec 16, 2015; **Published:** Dec 26, 2015; **Paper Id.:** IJTFTFEB20161

Original Article

INTRODUCTION

Surface colour measurement and colour matching has an important role in the objective determination of the appearance of colour. Colourimetric research studies were almost fully effective in qualifying the colour of uniform colour surface (uniform colour printed-paper, fabrics woven from uniform colour thread, fabrics produced with dyeing or printing.

The complexity of textile products, the diversity of textures, and the materials used produce variable colour, which was dependent on several parameters, such as illumination, spectral distribution of the colour stimulus, as well as the surface state of the textile. This surface state was presented in several forms according to its utility and the parameters of its construction, leading to a difference in colour from one structure to another [1].

Colour fastness is a resisting property of textile materials. To resist the colour loosing or reducing from the textile material surface during different mechanical, physical and chemical treatment is called colour fastness.

Importance of Colour Fastness

Colour fastness property of textile materials especially fabric is very important for processing and using. It is the property to withstand colour reducing from the surface of textile materials during undergoing different process and treatment. If the colour fastness property of fabric is not improved it indicates that the fabric was not dyed satisfactorily. On the other hand the chemicals and dyes selected for dyeing are not appropriated as compared

to fabric criteria. It can also be said that dyeing process and finishing of the fabric are not improved. As a result, due to lacking of colour fastness, there will be shade variation in the fabric which is a major fault in the eye of buyer. More over colour bleeding may occur more during washing, rubbing, perspiration etc. If the finished garments are made by this type of fabric of low colour fastness property, colour will be fade or bleed during washing and using [2].

The first known use of the word colour fast was in 1916. In general, clothing should be tested for colour fastness before using bleach or other cleaning products. Light fastness, wash fastness, and rub fastness are the main forms of colour fastness that are standardized and normally exposed in textile manufacturing and in daily use. The light fastness of textile dye is categorized from one to eight and the wash fastness from one to five. The higher the number the better fastness is obtained [3].

Factors Affecting the Colour Fastness Properties

- The chemical nature of the fiber. For example, cellulosic fibers dyed with reactive or vat dyes will show good fastness properties. Protein fibers dyed with acid mordant and reactive dyes will achieve good fastness properties and so on. That is to say compatibility of dye with the fiber is very important.
- The molecular structure (e.g.) of a dye molecule: If the dye molecule is larger in size, it will be tightly entrapped inside the inter-polymer chain space of a fiber. Thus the fastness will be better.
- The manner in which the dye is bonded to the fiber or the physical form present.
- The amount of dye present in the fiber i.e. depth of shade. A deep shade will be less fast than a pale or light shade.
- The presence of other chemicals in the material.
- The actual conditions prevailing during exposure [4].

Types of Colour Fastness

Colour fastness of textile materials can be classified into different way like as:

- Light fastness.
- Washing fastness.
- Rubbing fastness.
- Perspiration fastness.
- Water fastness
- Colour fastness to bleaches and chemicals.

Colour Fastness to Wash

Colour fastness to wash is very important for dyed materials. There are varieties of testing procedure because:

- Washing condition may vary from one country to another.
- The method depends on the use of dyed goods.
- To evaluate repeated washing accelerated test methods are used.

The degree of fading and staining of dyed materials for washing depends upon the following factors:

- Temperature range may be from 40 to 45
- The type and amount of detergent added to dye bath. In testing procedure a standard detergent used.
- The washing liquor to goods ratio.
- The hardness of water.
- The rinsing drying or pressing methods used to restore the sample after the washing test. Colour fastness to wash is measured using the wash wheel.

Principle of Colour Fastness to Washing

Tested materials in contact with specified adjacent fabric are laundered, rinsed and dried. The composite sample is treated under appropriate condition in a chemical bath for recommended time. The abrasive action is accomplished by the use of liquor ratio and an appropriate number of steels balls. The change in colour of the dyed sample and the staining of the adjacent fabric is assessed by recommended grey scale [5].

Colour Fastness to Light

Light fastness is the degree to which a dye resists fading due to light exposure. Different dyes have different degrees of resistance to fading by light. All dyes have some susceptibility to light damage, simply because their strong colours are indications that they absorb the wavelengths that they don't reflect back. Light is energy, and the energy that is absorbed by pigmented compounds may serve to degrade them or nearby molecules. For measuring the light fastness the Xenon Arc device is been used.

Dyes Which are More or Less Lightfast

The least lightfast dyes that are in use include the basic dyes, which are noted for their brilliant colours, but are extremely light-sensitive when used on natural fibers; they are more frequently used on synthetic fibers and also, when dissolved in alcohol, as silk paint. Acid and reactive dyes are much more lightfast. Direct dyes are not, on the whole, particularly lightfast, but there are a few direct dyes that are so lightfast that they may outperform similar shades of acid or fiber reactive dye. Vat dyes, such as indigo, may be more lightfast than other types of dyes.

Note that the wash fastness tests are completely different for protein fibers such as wool, which are assumed to be hand-washed in cool water or dry-cleaned, than for cellulosic fibers, which are assumed to be laundered harshly. The wash fastness tests results for fiber Reactive Dyes show what happens when items are washed at a temperature of 205°F (96°C), a far harsher test than that used for acid dyes, which are tested at 105°F (40°C). All fiber reactive dyes may be assumed to be far more washing fast than any acid dye [5].

Colour Fastness to Rubbing

Rubbing fastness is determined by the equipment called AATCC crock meter. Grey scale for staining also used for this.

The rubbing fastness tester checks the colour transferred from the surface of a coloured textile material to other surface by rubbing in dry and wet condition. It is applicable to textiles made from all fiber in the form of yarn or fabrics

whether dyed or printed or otherwise coloured. The Crock meter is been used to determine the colour fastness to rubbing or crocking.

Principle of Determining Rubbing Fastness

- A coloured test specimen is rubbed with white crock test cloth under controlled conditioning.
- Colour transferred to the white cloth is assumed by a comparison with grey scale for staining and a grade is assigned [5].

Assessing of Colour Change

The assessment of colour and colour change is the most important part of testing dyes and colours. Incorrect colour measurement wastes time and money and can result in a substantial claim for compensation from a customer. Colour is measured by measuring the reflected light from a sample over a variety of wavelengths. Each colour has its own reflectance fingerprint defined by the percentage of light reflected at a given wavelength. A reflectance curve is measured in the visible region for a colour and is plotted as percentage reflectance (%R) versus wavelength. An organization called CIE (Commission Internationalede l'Eclairage) determined standard values that are used worldwide to measure colour. The values used by CIE are called L, a* and b* and the colour measurement method is called CIELAB. L* represents the difference between light (where L*=100) and dark (where L*=0). A* represents the difference between green (-a*) and red (+a*), and b* represents the difference between yellow (+b*) and blue (-b*). Variables of L*, a*, b* or E* are represented as delta L*, delta a*, delta b* or delta E*, where delta E* = delta (delta L*2+delta a*2+delta b*2). It represents the magnitude of the difference in colour, but does not indicate the direction of the colour difference (figure 1).*

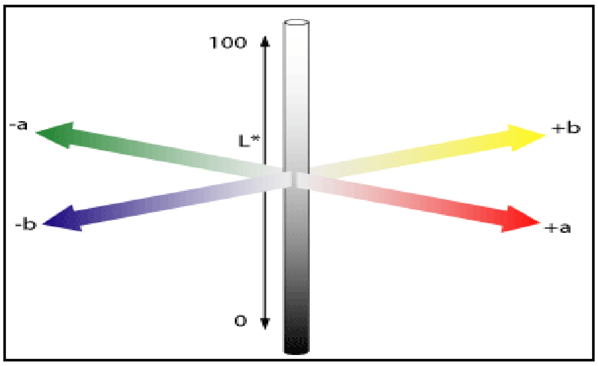


Figure 1: CIELAB Coordinate System

Visual Assessment

The most well-known and used system of visual assessment is the grey scale. Grey scales are used as the rating system for most standard test methods as they are widely available, low cost and easily used. There are two types of grey scales. One set measures the change in shade of a coloured textile and the other measures the degree of staining in an adjacent fabric. The two grey scales are shown in figure 2. Grey scales have a rating of 1 to 5 with 1 being the worst colour performance and 5 being the best. Each rating can be split so that there are nine available ratings within the grey scale system [5].

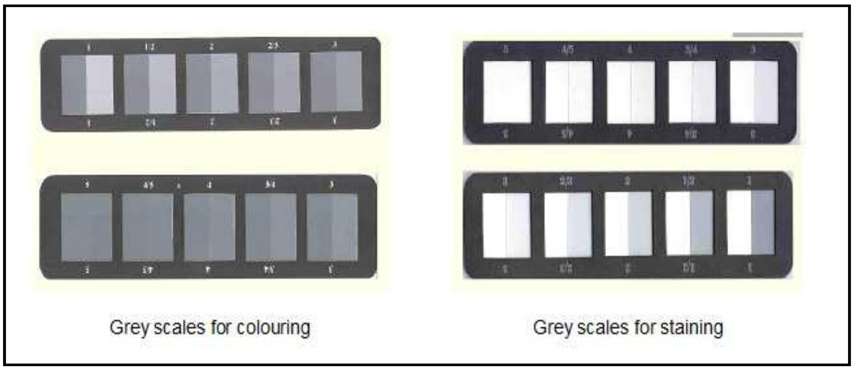


Figure 2: Grey Scales for Measuring the Colour Fastness

Automated Assessment

The use of spectrophotometers for fabric colour measurement has been adopted widely in the last 10 years. This technique has not changed much over the last 30 years; however, data collection and management of the spectrophotometer has. A spectrophotometer can provide a huge amount of measured and calculated information including ΔE^* values, multiple light source colour information, comparisons with measured or inputted standards, colour histograms of multiple batches, reflectance versus wavelength graphs and recipe advice [5].

During clothing production, textile fabrics have to been sewn together to become a ready wear garment. A seam is a joint between two pieces of fabric and is defined as ‘the application of a series of stitches or stitch types to one or several thicknesses of material’ [6]. From the definition, there are two major components of seam which include stitches and materials in the form of fabrics. Seam quality is thus influenced by two main factors which are the fabric mechanical properties and sewing parameters [7].

In the literature, several studies were carried out to model the textile properties. Numerous works were developed to model the influence of the textile structure on colour [1, 8, 9] or to improve the colour fastness properties [10]. The effect of seam on the mechanical properties had been studied by a lot before [11, 12, 13]. But no one has investigated, if the sewing parameters effect on changing the properties of the colour fastness on the seam area have or not.

Aims of the Study

- Study the influence of seam conditions on changing the colour fastness properties.
- Determine the best sewing parameters to minimize the change in the colour fastness.

MATERIALS AND METHODS

Materials

Tests were performed with three twill weave fabrics varying in their fabric contents, weight per unit area, thickness and fabric density. Specification of investigated materials is listed in table 1.

Table 1: Specifications of Investigated Materials

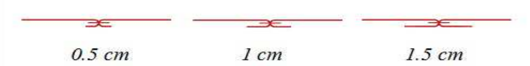
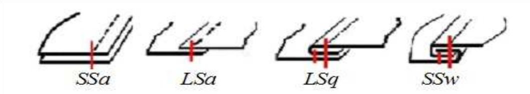
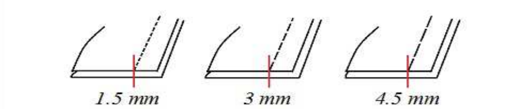
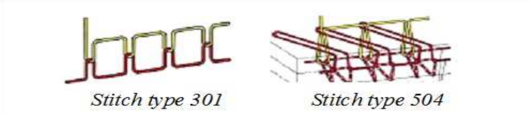
Fabric Code	Fabric contents	Weave structure	Weight per unit area [g/m^2]	Thickness [mm]	Fabric density/cm	
					Warps/cm	Picks/cm
M 1	50% CO, 50% PES	Twill 1/2	178,7	0.40	37 (Ne 28)	24 (Ne 18)
M 2	50% CO, 50% PES	Twill 2/1	227,34	0.36	44 (Ne 17)	24 (Ne 17)
M 3	50% CO, 50% PES	Twill 1/2	206,14	0.38	42 (Ne 20)	24 (Ne 17)

Methods

Sewing was done using industrial sewing machines under particular sewing conditions that are commercially adopted by apparel manufacturers in apparel manufacturing. Sewing thread 100% spun polyester Ne 40/2 was used for sewing all specimens. With lock stitch sewing machine three seam allowance levels, four seam types and three stitch lengths are tested. The lockstitch 301 and multi-chain over lock stitch 504 are tested also. Table 2 illustrates the experimented sewing factors.

All samples are sewn in the middle and parallel with the warp direction of the fabrics.

Table 2: Sewing Factors used in the Experiments [14, 15]

Sewing Factors	Description	Illustration
Seam allowance	0.5 cm , 1 cm , 1.5 cm	
Seam type (by lock stitch 301)	SSa, LSa, LSq, SSw.	
Stitch length	1.5 mm, 3 mm , 4.5 mm	
Stitch type	Stitch 301, Stitch 504	

Evaluation of fastness properties of seamed textile fabrics is done by measuring washing, light, rubbing fastness values in the seam area. Colour fastness to wash is measured using the Wash wheel (figure 1) according to AATCC Test method 61-2003 [16]. Colour fastness to light is measured using the Xenon Arc device (figure 2) according to AATCC test method 16-2004 [17]. For measuring the colour fastness to crocking (rubbing), the Crockmaster (figure 3) is used and the evaluation of the test is done according to AATCC test method 8-2005 (in the wet condition) [18].

For evaluating the changes of colours, the LabScan XE Reflected Colour Spectrophotometer is used.

RESULTS AND DISCUSSIONS

In order to determine the influence of seams on the colour fastness properties, all specimens of the three materials were sewn with the same sewing parameters and machine settings, which are listed before in table 2. The specimens were tested in only the warp direction of the fabrics.

The results and discussion would concern with the effects of seam allowance, seam types, stitch length and stitch types on the colour fastness to wash, light and rubbing in the wet condition separately in sequence.

Influence of Seam Allowance on the Colour Fastness Properties

Results in figure 3 indicate, that the seam allowance a significant effect on changing the colour fastness properties has.

We found, that by seam allowance of 1 cm (the standard case), recorded the highest effect of the seam on changing the three tested colour fastness properties (wash, light and rubbing. The results of seam allowance 0,5 cm and 1 cm are near. Results pointed to, to reduce the change of the colour fastness; man can reduce or increase the value of seam allowance than on the normal case. Regression equations from second degree and the correlation factors are calculated and presented. We introduce only some equations from the material 1.

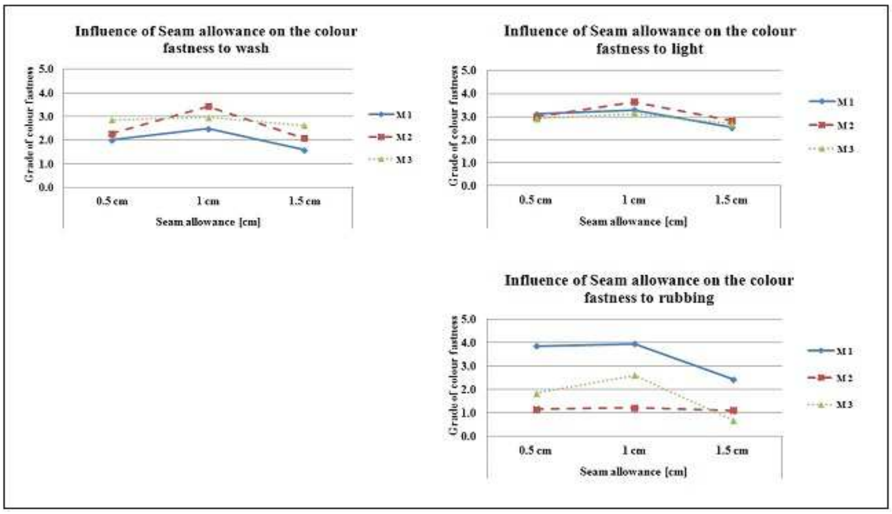


Figure 3: Effect of Seam Allowance on the Colour Fastness Properties

Influence of the seam allowance on the change of colour fastness properties can be shown from the next three equations 1, 2 and 3, as following:

$y_{m1(Wash)} = -0.68x^2 + 2.51x + 0.18$ (Equ. 1)

With correlation factor ($R^2_{m1(wash)} = 1$)

$y_{m1(Light)} = -0.47x^2 + 1.59x + 1.99$ (Equ. 2)

With correlation factor ($R^2_{m1(Light)} = 1$)

$y_{m1(Rub)} = -0.8x^2 + 2.49x + 2.17$ (Equ. 3)

with correlation factor ($R^2_{m1(Rub)} = 1$)

Where:

Y is the change in the degree of colour fastness

X is the seam allowance level.

Change of colour fastness to wash is (2.48), by colour fastness to light is (3.01) and by colour fastness to wet

rubbing is (2.09). The acceptable degree of Objective Evaluation of the change of the colour is from 1 to 2.

Influence of Seam Type on the Colour Fastness Properties

To investigate the effect of the seam types on the colour fastness properties, specimens have to been sewn with some different

seam types, which vary in the number of fabric layers within the seam area. All of the seam types are done by the lock stitch type 301. The presented results in figure 4 pointed to the significant effect for this factor.

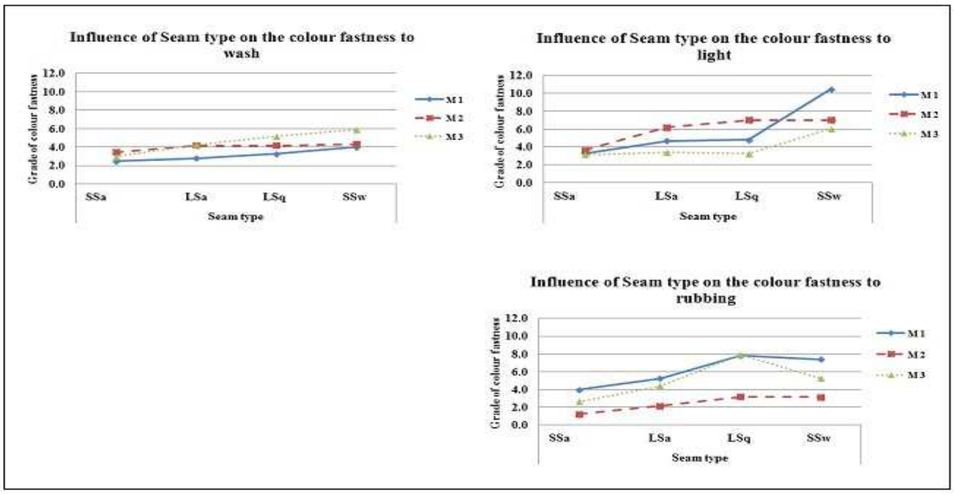


Figure 4: Effect of Seam Types on the Colour Fastness Properties

It is very clear, that the effect of the seam type depends on the number of the layers on the seam area. The lapped seam with four layers (SSw) had the highest effect on the change of colour, then came the lapped seam with three layers (LSq), at the end came the two layers seams (LSa and SSa). The regression equations from first degree and the correlation factors (by material 1) are calculated and presented.

Effect of the seam types on change of colour fastness properties can be explained from the next three equations 4, 5 and 6, as following:

$$y_{m1(Wash)} = 0.5x + 1.875 \quad \text{(Equ. 4)}$$

with correlation factor ($R^2_{m1(Wash)} = 0.9624$)

$$y_{m1(Light)} = 2.167x + 0.39 \quad \text{(Equ. 5)}$$

with correlation factor ($R^2_{m1(Light)} = 0.7727$)

$$y_{m1(Rub)} = 1.28x + 2.89 \quad \text{(Equ. 6)}$$

with correlation factor ($R^2_{m1(Rub)} = 0.8297$)

Because of the different seam type, occurred a change of colour fastness to wash, the average degree is (3.91), by colour fastness to light is the average degree (5.24) and by colour fastness to wet rubbing the average degree is (4.51). The acceptable degree of Objective Evaluation of the change of the colour is from 1 to 2. It can be very noticeable the hug effect of the seam types on the change of colour fastness testes.

Influence of Stitch Length on the Colour Fastness Properties

In order to investigate the influence of stitch length on change of the colour fastness, three levels of stitch length 1.5 mm, 3 mm and 4,5 mm) are used. Sewing is done only by using the lock stitch type 301. Results in figure 5 confirm that the stitch length an effect of the colour change by the three tests has. It is obviously, that the hug effect was by the stitch length 3 mm, which consider the standard stitch length. By reducing or increasing the stitch length the degree of colour change would be smaller.

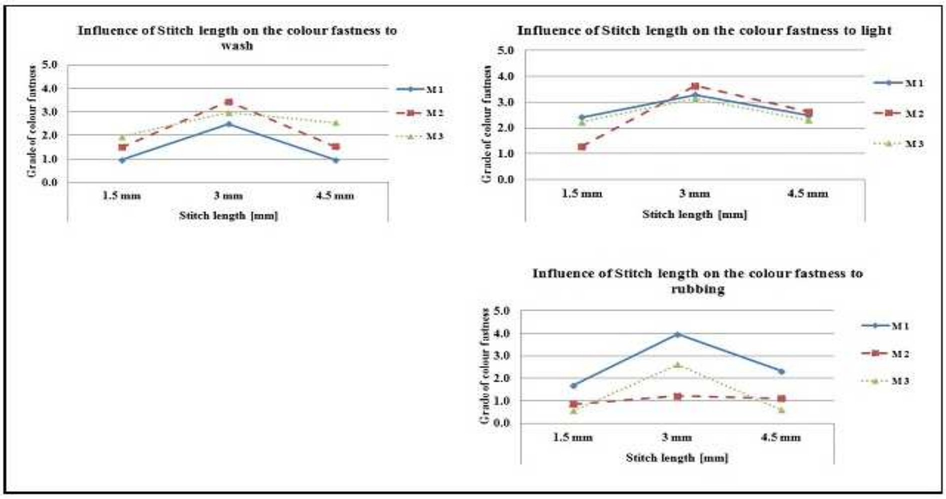


Figure 5: Effect of Stitch Length on the Colour Fastness Properties

Regression equations from second degree and the correlation factors of (material 1) would be presented to confirm this result.

Influence of the stitch type on change of colour fastness properties has to be cleared from the next three equations 7, 8 and 9, as following:

$y_{m1(Wash)} = -1.525x^2 + 6.105x - 3.63$ (Equ. 7)

with correlation factor ($R^2_{m1(Wash)} = 1$

$y_{m1(Light)} = -0.84x^2 + 3.4x - 0.15$ (Equ. 8)

with correlation factor ($R^2_{m1(Light)} = 1$)

$y_{m1(Rub)} = -1.955x^2 + 8.135x - 4.5$ (Equ. 9)

with correlation factor ($R^2_{m1(Rub)} = 1$)

According to the different stitch length happen a change of colour fastness to wash, the average degree is (2.03), by colour fastness to light the average degree is (2.60) and by colour fastness to wet rubbing the average degree is (1.65). The acceptable degree of Objective Evaluation of the change of the colour is from 1 to 2.

It can be said, that the effect of the stitch length on change of colour fastness testes is smaller than the effect of other sewing factors.

Influence of Stitch Type on the Colour Fastness Properties

In this case only two stitch types are tested. The lock stitch 301 and the over-lock chain stitch 504. From the results in figure 6, it can be visible, that the effect of the over-lock chain stitch 504 is bigger than the lock stitch 301 on changing the colour.

The average degree of the change of colour by washing test are (2.96) for stitch 301 and (3.52) for stitch 504. By colour fastness to light, recorded the average degree of the colour change (3.35) by stitch 301 and (3.90) by stitch 504. By wet crocking test were the average of the degree by stitch 301 (2.59) and by stitch 504 (3.12).

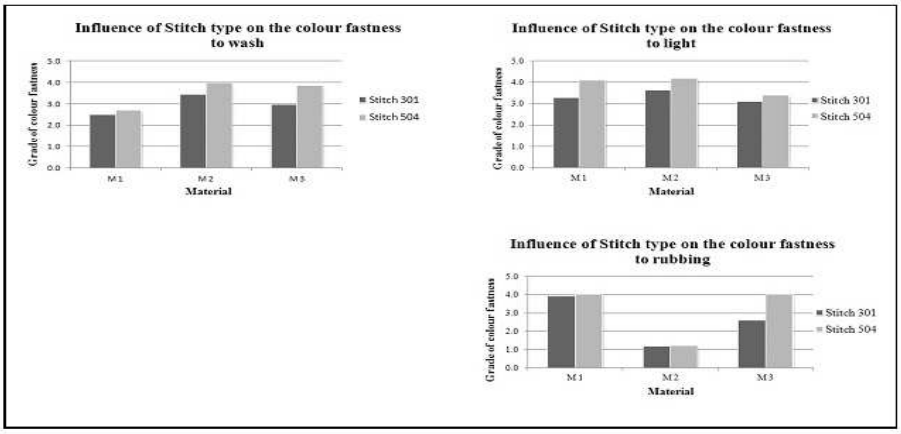


Figure 6: Effect of Stitch Type on the Colour Fastness Properties

It can be summarized, that according to the different stitch type happen a change of colour fastness to wash, to light and to rub. The acceptable degree of Objective Evaluation of the change of the colour is from 1 to 2 degree. It can be said, that the effect of the stitch type on change of colour fastness testes is obviously and significant.

Determining of the Degree of the Colour Transfer by the Crocking Test

As mentioned before there are two types of grey scales. One set measures the change in shade of a coloured textile and the other measures the degree of staining in an adjacent fabric. We make the same assessment by the objective evaluation of the effect of seams on colour fastness to rubbing. First effect had been already presented and explained in the discussion. Second type would be shown in figure 7. Results of the influence of seam allowance on the colour transfer by crocking test indicated to the same behaviour by the degree of colour change. By seam allowance 1 cm is the highest effect, and then came the two other tested seam allowance levels. The degree of the colour transfer of staining is (15.92).

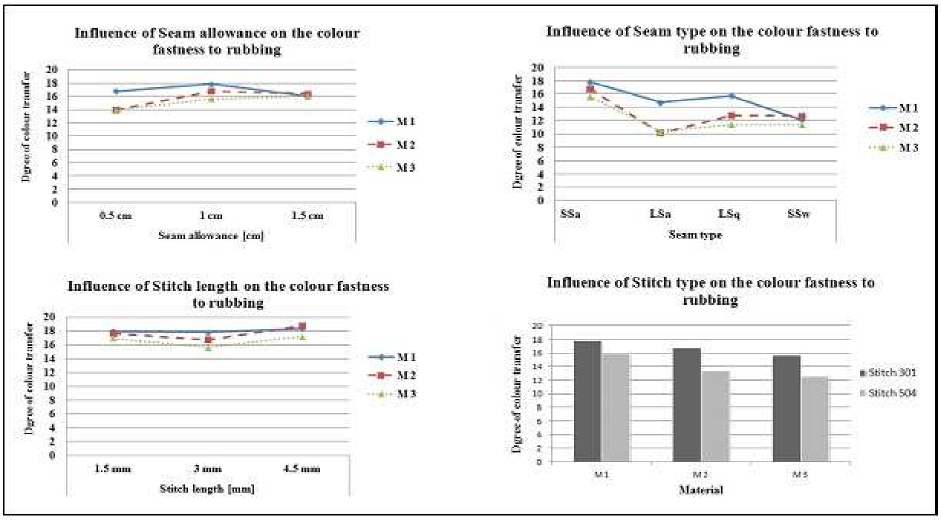


Figure 7: Value of Colour Transfer by Crocking Test

By the factor of seam types show the results an opposite case, with the lapped seam type with four layers (SSw), recorded the smallest value of the colour transfer of the staining. It perhaps referred to the thickness of the seam, which had consists of four layers and it is difficult to transfer the colour from the four layers. The average of degree of colour transfer is about (13.48). The stitch length has an average degree of colour transfer (17.89), but the different between the three stitch length levels is rare. It is due to the stitches are hidden under the layers and has no different effect.

For the effect of the stitch type, present the results an opposite behaviour than by the change of the colour. It is also logical results, because the seam wide by lock stitch 301 is bigger than by the over-lock chain stitch 504. So the colour can be transferred better. The average degree of colour transfer of staining is (16.79) by lock stitch 301 and (13.93) by over-lock chain stitch 504.

To determine the best sewing parameters to minimize the colour change, we could say that for **the seam allowance**, it is better to reduce or increase the seam allowance than the standard case (1 cm) to get a better result of the colour fastness. For **the seam type**, it is obvious that seams with fewer layers are colour fast than with more layers. The effect of **stitch length** is rare than other investigated sewing parameters, but in general it is better to increase or decrease the stitch length than the normal case (3 mm). The effect of the **stitch type** indicated to, sewing with over-lock chain stitch has little effect on changing the colour than with the lock stitch.

Influence Factors of Sewing Parameters on Colour Fastness Properties

To summarize the effect of all sewing parameters on the colour fastness properties, the effect factors of every sewing parameter on individual colour fastness property is presented. From figure 8, it can be said, that the seam type has the highest effect on the change of colour fastness to wash, light and rubbing. The influence factor is about (34 % to 41%) by different materials. Next comes in order the factor of the stitch type, which records an influence factor between (21% to 30%) by different materials. The third effective factor is the seam allowance. The influence factor of the seam allowance is (20 % to 22 %) for all tested materials. At the end comes the stitch length, which has the lowest effect on the change of the colour change. The influence factor is about (16 % to 18 %) for all tested materials.

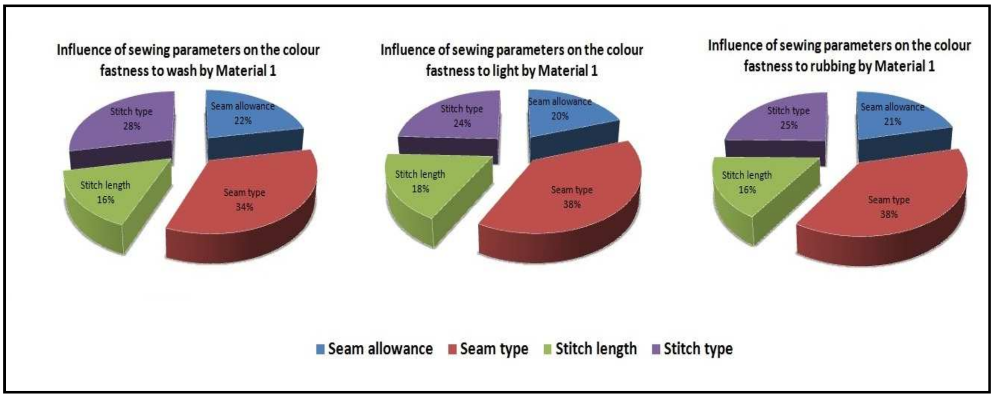


Figure 8: Influence of Sewing Parameters on the Colour Fastness Properties by Material 1

CONCLUSIONS

Colour fastness is one of the important factors in case of buyers demand. Colour fastness is a term used in the dyeing of textile materials, meaning resistance of the material's colour to fading or running of a dyed or printed textile materials to various types of influences e.g. water, light, rubbing, washing, perspiration etc. The term is usually used in the context of clothes. In this study the influence of the seam parameters such like seam allowance, seam types, stitch length and stitch type, on the colour fastness to wash, to light and to rubbing, is investigated and evaluated. Results confirmed that the seam has significant effect on change of the colour fastness properties. To determine the best sewing parameters for the colour fastness properties, it is better to reduce or increase the seam allowance than the standard case. Seams with fewer layers are better than with more layers. Stitch length has little effect than the other factor, but it is better to reduce or increase the stitch density than the normal case. And sewing with over-lock stitch is better than with lock stitch. The seam type has the highest effect on the change of the colour, and then comes the stitch type. Third position has the seam allowance and at the end comes the stitch length.

REFERENCES

1. *Shanbeh M., Khalili H., Hajrasouliha J., Shiasi A.: Evaluation of Colour Difference, Whiteness, and Luster of Multifilament Polyester Woven Fabrics, Journal of Engineered Fibers and Fabrics, Volume 9, Issue 3, 2014.*
2. *http://www.definetextile.com/2013/04/colour-fastness_25.html.*
3. *https://en.wikipedia.org/wiki/Colour_fastne.*
4. *http://textilelearner.blogspot.com/2012/11/different-colour-fastness-tests.html.*
5. *HU J.: Fabric testing, Woodhead Publishing Limited, 2008.*
6. *BS3870: Stitches and seams, Part, 21991*
7. *Abdul Ghani S.: Seam Performance: Analysis and Modelling. Ph.D thesis, University of Manchester, England, 2011.*
8. *Deveoglu O., Sahinbaskan B., Torgan E. and Karadag R.: Investigation on colour, fastness properties and HPLC-DAD analysis of silk fibres dyed with Rubia tinctorium L. and Quercus ithaburensis Decaisne, 2012 Society of Dyers and Colourists, Colour. Technol.*
9. *Khuangthip B., Chulakup S., Jatuphatwarodom S., Cholsakorn S. And Mongkholrattansit R.: Evaluation of Physical properties of Twill weave Morhom fabric, RMUTP International Conference: Textiles & Fashion 2012 July 3-4, 2012, Bangkok Thailand.*

10. *Yaman N., Ozdogan E., Seventekin N.: Improvement Fastnesses and Colour Strength Of Pigment Printed Textile Fabric, Journal of Engineered Fibers and Fabrics, Volume 7, Issue 2 – 2012.*
11. *Seif, M.: INVESTIGATING THE SEAM SLIPPAGE OF SATIN FABRICS, International Journal of Textile and Fashion Technology (IJTFT) ISSN(P): 2250-2378; ISSN(E): 2319-4510 Vol. 4, Issue 5, Oct 2014, 1-10*
12. *Gribaa S., Ben Amar S., Dogui A.: Influence of sewing parameters upon the tensile behavior of textile assembly, International Journal of Clothing Science and Technology Vol. 18 No. 4, 2006 pp. 235-246.*
13. *Seif, M.: Bereitstellung von Materialkennwerten für die Simulation von Bekleidungsprodukten (English: Determination of Material parameters for the simulation of clothing products), Ph. D. Thesis, Faculty of Engineering, Technical University of Dresden, Germany, 2007.*
14. *Carre, H., Llatham, B.: The technology of clothing manufacture, Blackwell scientific publication, second edition, 1994.*
15. *American & Efird, Inc., SEAMS DRAWINGS – INDEX, 2006.*
16. *AATCC Test method 61-2003: Colour fastness to Laundering, Home and Commercial: Accelerated, 2003.*
17. *AATCC test method 16-2004: Colour fastness to Light, 2004.*
18. *AATCC test method 8-2005: Colour fastness to Crocking: AATCC Crockmeter method, 2005.*